Front-end design of National Synchrotron Light Source II

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Poster paper

Front-end design of National Synchrotron Light Source II

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National Synchrotron Light Source II (NSLS-II) will be a 3-GeV, 792-m circumference third-generation synchrotron radiation facility with ultralow emittance and extremely high brightness. Front ends are required to transmit synchrotron radiation from the storage ring to the beam line while providing equipment and personnel protection. There will be up to 57 front ends in the NSLS-II facility with six in the baseline. Original designs are being developed and will be manufactured for three non-canted in-vacuum undulators, one canted in-vacuum undulator, one elliptically polarized undulator and one damping wiggler. Bending magnet and three-pole wiggler front ends are also being designed. Power densities range from 0.3 to 89.8 kW mrad^{-2}, with total powers ranging from 0.34 to 64.5 kW. All components intercepting synchrotron radiation are water cooled and were analysed to confirm acceptable thermal limits.

All major front-end components and the design process are described, including masks, collimators, shutters and slits. Thermally stable stands with XY stages were developed and will be shown along with an external lead safety shutter.

Front-end types have been broken up into three categories because of their heat loads on power-absorbing devices: bending magnets/three-pole wigglers, undulators and damping wigglers. All front ends share the basic configuration shown above (figure 1). From left to right (beam direction), the front end consists of a bending magnet photon shutter, a slow gate valve, a 1st X-ray beam position monitor, a 2nd X-ray beam position monitor, a fixed mask, a lead collimator, a slit assembly on thermally stable stands and XY stages, a photon shutter, fast gate valve, a 2nd lead collimator, a redundant external lead safety shutters, ratchet wall collimator (not shown) and a slow gate valve (not shown). The bending magnet photon shutter is approximately 15.5 m from the centre of the insertion device (ID) straight section and the ratchet wall collimator is approximately 24 m from the centre of the straight section.

The design of the front end starts by defining the beam line specifications (ID attributes, synchrotron fan size required in the first optics enclosure and stability requirements) and the sequence of components with their nominal sizes. A plan

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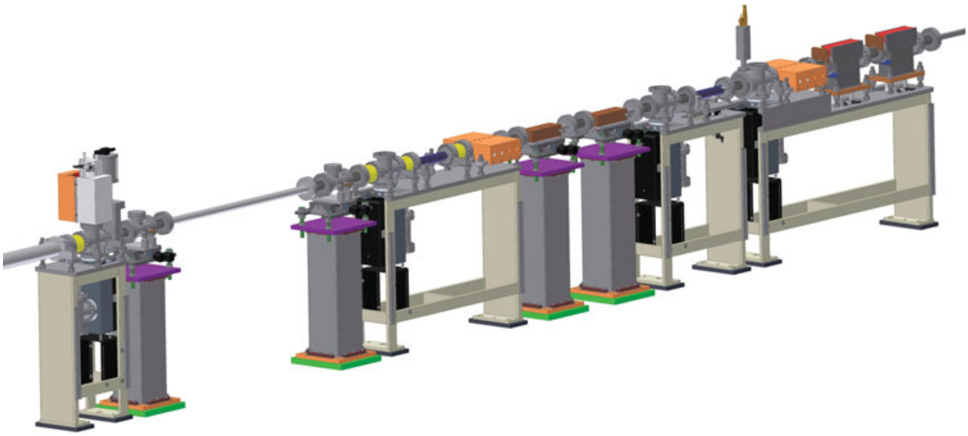

FIGURE 1.

view of the front end is then drawn with horizontal and vertical synchrotron anamorphic ray tracings. From the ray tracings, aperture sizes are defined for all components, including the masks and Bremsstrahlung collimators. With the Bremsstrahlung collimators sized and located, vertical and horizontal Bremsstrahlung anamorphic ray tracings are drawn. A detailed design of components and thermal analysis completes the process.

Heat-absorbing devices (masks, slits and the photon shutter) are all water cooled and manufactured as gold-brazed assemblies, including a Glidcop body and stainless steel flanges. Thermal analysis shows the peak temperature of the mask for a 3 m IVU 20 at ~300°C (figure 2). Location ~17 m from the centre of the straight section, absorbed power ~8 kW, incidence angle (v) 2.7°, incidence angle (h) 3°, length of fixed mask 24 cm and peak temperature ~300°C.

An approach being considered for heat-absorbing devices is shown below (figure 3). A cylindrical Glidcop body is machined on its outer diameter to include a spiral water channel along its length. A stainless steel sleeve is positioned over the channel and brazed in place. This approach reduces manufacturing costs relative to earlier designs while improving heat transfer and reducing water-induced vibration.

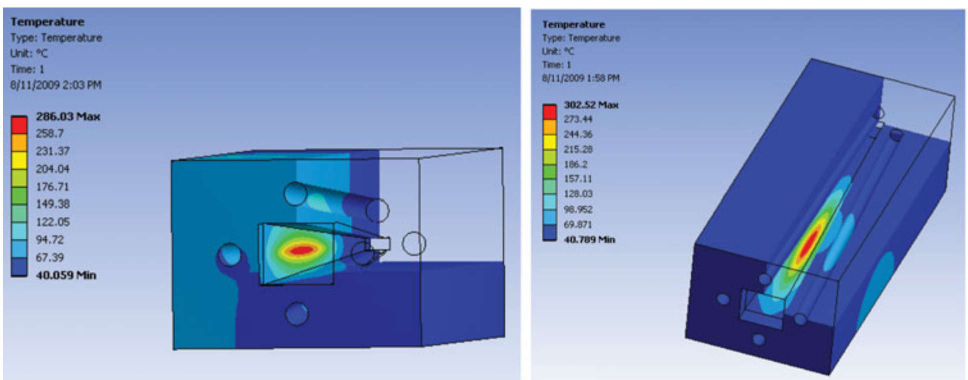

FIGURE 2.

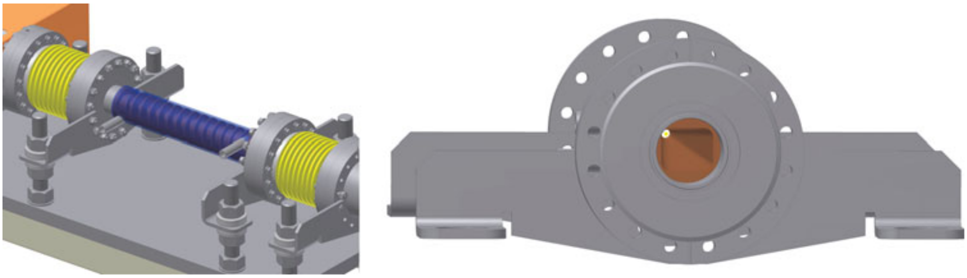

FIGURE 3.

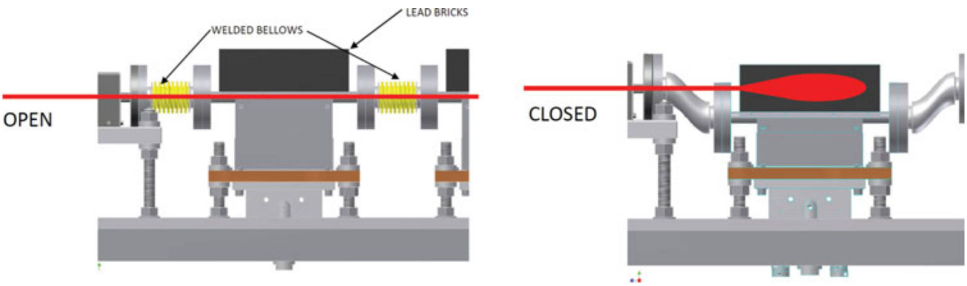

FIGURE 4.

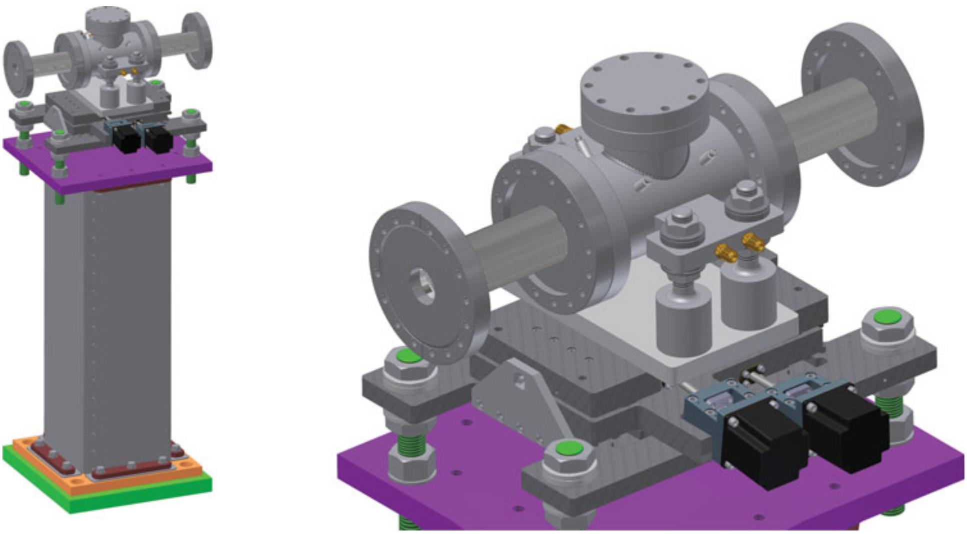

FIGURE 5.

Dual Bremsstrahlung safety shutters are included in all front ends immediately upstream of the ratchet wall collimator. The design includes external lead shielding mounted over a stainless steel vacuum pipe (figure 4). The lead/tube assembly moves 63.5 mm vertically between welded bellows. Prior to actuating the safety shutter(s), the photon shutter must be closed. A series of fatigue tests have been performed on the bellows, with failures ranging from 880 000 cycles to over 6 000 000. A 20-year lifetime is considered equal to100 000 cycles.

The X-ray beam position monitors and slits are mounted on thermally stable Invar stands (figure 5). The stands are made up of two 3-mm-thick halves overlapping at two corners and riveted and then welded together. An Invar mounting plate and Invar threaded rods support a stage assembly to allow transverse and vertical positioning of the device. The thermal stability requirement of the stand assembly is 200 nm and the positioning resolution of the stage is better than 1 μm.

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